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TITLE: Rendering device and method

Abstract Paragraph:
In a navigation device (Unv), a processor 1 reads from a storage 4 directional object data (Ddr) onto a working area 3. The directional object data (Ddr) has a message plane and a plain plane, thereby representing a directional object whose planes are facing in each different direction. Based on the positional relationship between the user's current position and the directional object, the processor 1 determines which to render the message plane or the plain plane of the directional object. In the case of the message plane, the processor 1 renders it opaque. On the other hand, the processor 1 renders the plain plane transparent or translucent. In this manner, the resulting display image data generated by the navigation device (Unv) can represent maps meeting the user's demands and needs.

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Summary of Invention Paragraph:
[0004] The above type of rendering device has been often incorporated in a navigation device. EP Patent No. 1,024,467, Japanese Patent Laid-Open Publication No. 2000-276609, and EP Patent No. 777,206 each disclose such a navigation device with the rendering device incorporated therein. In this Background Art section, those navigation devices are respectively referred to as, in that order, a first, second, and third navigation devices. In the below, those navigation devices are each described for a rendering process executed therein.

Summary of Invention Paragraph:
[0005] In a rendering process, in the first navigation device, a distance from the current vehicle position to any object to be rendered locating in a close range of the vehicle position is calculated. If the calculated distance is equal to a predetermined threshold value or smaller, the object is three-dimensionally rendered. If exceeding, on the other hand, the object is two-dimensionally rendered, resulting in lower viewability compared with the one three-dimensionally rendered. Herein, the object denotes an element of a display map, e.g., building.

Summary of Invention Paragraph:
[0006] In the second navigation device, a distance from the current vehicle position to any object to be rendered locating in a close range of the vehicle position is also calculated. Based on the calculated distance, determined here is a color density of the object to be rendered. Herein, the object denotes a polygon representing a road in a display map.

Summary of Invention Paragraph:
[0007] In the third navigation device, route search is firstly done for guiding the vehicle. When the vehicle comes in a predetermined range from each intersection on the found route, any objects (typically landmarks) facing to the road leading to the intersection are to be rendered on a map.

Summary of Invention Paragraph:
[0008] The issue here is that, as in the first and second navigation devices, changing the manner of rendering objects based on the distance from the vehicle position to the target object often fails to result in maps meeting the users' demands and needs.

Summary of Invention Paragraph:
[0009] Referring to FIGS. 22A to 22C, the problem is described in more detail. FIG. 22A shows an intersection C1, to which first to third roads W1 to W3 are connected. Presumably, the vehicle is allowed to go through the intersection C1 from the first road W1 to the second road W2, but prohibited to go in the opposite direction, i.e., from the second road W2 to the first road W1. Under such a presumption, there is a "No Entry" sign TS1 provided in the vicinity of the intersection C1. As shown in FIG. 22B, the road sign TS1 shows a message on a main plane TS11 facing to the second road W2, but as shown in FIG. 22C, its opposite plane TS12 facing to the first road W1 shows no message.

Summary of Invention Paragraph:
[0010] When the vehicle approaches the intersection C1 from the direction of the second road W2, the first and second navigation devices display a map as shown in FIG. 22B. With such a map, the user in the vehicle will see the plane TS11.

Summary of Invention Paragraph:
[0011] If the vehicle approaches the intersection C1 from the direction of the first road W1, on the other hand, displayed on the first and second navigation devices is a map as shown in FIG. 22C. In this displayed map, the plane TS12 shows no message of "No Entry", and thus there is no need to include the road sign TS1 as long as the user sees the object from the first road W1 side. Even so, the first and second navigation devices both fully and clearly render the plane TS12 of the road sign TS1 as an object. As a result, the road sign TS1 blocks the user's view in the displayed map for the area therebehind, which is a part where the user wants to see rather than the plane TS12 of the road sign TS1 having no beneficial use in this case. This proves that changing the manner of rendering objects based on the calculated distance as by the first and second navigation devices is not an answer for maps meeting users' demands and needs, thus considered not driver friendly.

Summary of Invention Paragraph:
[0012] The third navigation device bears the same problem as described referring to FIGS. 22A to 22C because objects on roads in the heading direction are explicitly rendered thereby.

Brief Description of Drawings Paragraph:
[0024] FIG. 8 is a flowchart of processes written in a navigation program 22 of FIG. 1 to be executed by a processor 1;

Brief Description of Drawings Paragraph:
[0033] FIGS. 17A and 17B are illustrations showing an optimal route Rpt to be rendered in step S51 of FIG. 16;

Brief Description of Drawings Paragraph:
[0038] FIGS. 22A to 22C are illustrations demonstrating problems in conventional navigation devices.

Detail Description Paragraph:

[0039] FIG. 1 is a block diagram showing the hardware structure of a rendering device Urnd1 according to a first embodiment of the present invention. Referring to FIG. 1, the rendering device Urnd1 generates display image data Ddp representing a map to be displayed on a display 8, and display image data Dgd for guidance (hereinafter, guidance image data Dgd). The rendering device Urnd1 includes a processor 1, a program memory 2, and a working area 3. The processor 1 is typically a CPU (Central Processing Unit), or an MPU (Micro Processing Unit). The program memory 2 is typically ROM (Read Only Memory), and stores a computer program 21 for rendering (hereinafter, rendering program). In the present embodiment, the rendering device Urnd1 is presumably incorporated in a navigation device Unv. Therefore, the program memory 2 stores also a computer program 22 for navigation (hereinafter, navigation program), and in accordance therewith, the processor 1 executes processes needed for navigation. The working area 3 is typically RAM (Random Access memory), and used when the processor 1 executes the rendering program 21 and the navigation program 22. In FIG. 1, to realize the navigation device Unv, the processor 1 of the rendering device Urnd1 is connected to a storage 4, a GPS receiver 5, autonomous navigation sensors 6, an input unit 7, and a display 8 to carry out data communications therewith.

Detail Description Paragraph:
[0040] Referring to FIG. 2, the storage 4 stores a cartographic database DBct. For route search by the navigation device Unv, the storage 4 also stores road network data Dnt.

Detail Description Paragraph:
[0049] The pairs of the coordinates string information Icsm and the color information Iccm are provided as many as object parts POdrm, which are structural elements of the message plane Ams as shown in FIG. 5A. In other words, there is a one-to-one relationship between the object parts POdrm and the pairs of the coordinates string information Icsm and the color information Iccm. Here, the object parts POdrm are all primitive, and the message plane Ams is not complete until every object part POdrm is rendered. The coordinates string information Icsm of FIG. 4 includes a plurality of three-dimensional coordinates (Xpm, Ypm, Zpm), with which an object part POdrm is defined by outline. Herein, Xpm is a latitude coordinate, Ypm is a longitude coordinate, and Zpm is a height coordinate. The coordinates string information Icsm also includes connection information about how those three-dimensional coordinates are specifically connected to one another. Generally, in the coordinates string information Icsm, those three-dimensional coordinates are so arranged that the object part POdrm can be drawn in a stroke, and the connection information accordingly indicates the resulting order. The color information Iccm defines with what color the object part POdrm is to be filled.

Detail Description Paragraph:
[0053] The pairs of the coordinates string information Icsp and the color information Iccp are provided as many as object parts POdrp, which are structural elements of the plain plane Apl as shown in FIG. 5B. Here, as are the object parts POdrm, the object parts POdrp are also all primitive, and the plain plane Apl is not complete until every object part POdrp is rendered. It should be noted here that, even if the message plane Ams and the plain plane Apl belong to the same directional object Odr, those shapes are not always disassembled into the same primitives. That is, the object parts POdrp and POdrm are not always the same. The coordinates string information Icsp of FIG. 4 includes, similarly to the coordinates string information Icsm, a plurality of coordinates (Xpp, Ypp, Zpp), and at least a unit of connection information, whereby an object part POdrp is defined by outline. The color information Iccp defines the color to fill in the object part POdrp.

Detail Description Paragraph:
[0054] Here, the coordinates string information Icsp and the color information Iccp are specifically exemplified. The plain plane Apl of FIG. 3B is assumed to be

renderable by a piece of object part POdrp1, which is solely in charge of the backside of the road sign as shown in FIG. 5B. Under such an assumption, the plain information Ip1 includes only a pair of the coordinates string information Icsp1 and the color information Iccp1. Here, the coordinates string information Icsp1 is composed of a plurality of three-dimensional coordinates for defining such an object part POdrp1 by outline. The color information Iccp1 defines the color to fill in the object part POdrp1.

Detail Description Paragraph:
[0062] The pair of the coordinates string information Icsn and the color information Iccn defines the non-directional object Ondr by shape and color, as do the pairs in the directional object data Ddr. The coordinates string information Icsn includes, for defining by outline an object part being a structural element of the non-directional object Ondr, a plurality of three-dimensional coordinates (Xndr, Yndr, Zndr). The coordinates string information Icsn also includes connection information about how those three-dimensional coordinates are to be connected one another for rendering the object part. The color information Iccn defines with what color the object part is to be filled.

Detail Description Paragraph:
[0063] Unlike the directional object data Ddr, the non-directional object data Dndr does not necessarily include information like the transparency information Itlm and Itlp, and the direction information Idrm and Idrp. This is because the user sees no necessity in the area behind the non-directional object Ondr, and thus all the rendering device Urnd1 has to do for the non-directional object Ondr is to render it with a given transparent gradient. Accordingly, the rendering program 21 previously includes the transparent gradient for the non-directional object Ondr, preferably "0". This keeps the non-directional object data Dndr from carrying unnecessary information, consequently the storage 4 in the navigation device Unv becomes relatively small in capacity.

Detail Description Paragraph:
[0065] In FIG. 2, the road network data Dnt may be of a known type, and represents a road network using nodes and links in the specific wide range described above. The nodes each specify, by two-dimensional coordinates, i.e., a latitude coordinate and a longitude coordinate, intersections and characteristic points typified by curving points of roads on the road network. The links each specify which node is connected to which, and include information about distances between any two characteristic points, and other information whatever needed.

Detail Description Paragraph:
[0066] In FIG. 1, the GPS receiver 5 receives information coming from artificial satellites assigned to the Global Positioning System (GPS). Based on the received information, the GPS receiver 5 calculates the current position of the navigation device Unv, i.e., of the user. The GPS receiver 5 then generates current position information Icp indicating the resulting current position, and then forwards it to the CPU 1. The autonomous navigation sensors 6 include a gyrocompass and a vehicle speed sensor, and detects in which direction the navigation device Unv is heading with what speed. Using the detection results, autonomous navigation information Ian is generated and forwarded to the CPU 1. The input unit 7 typically includes a remote controller and buttons. The display 8 is typically composed of a liquid crystal display.

Detail Description Paragraph:
[0067] Described next is the operation of the navigation device Unv structured as above. After the navigation device Unv is turned on, the processor 1 starts executing the navigation program 22 stored in the program memory 2. Here, FIG. 8 is a main flowchart of processes written in the navigation program 22 to be executed by the processor 1. In FIG. 8, the processor 1 receives the current position information Icp from the GPS receiver 5, and the autonomous navigation information

Ian from the autonomous navigation sensors 6. Then, the processor 1 operates as does a calculation section in claim 8, i.e., calculates the specific current position Pdtl of the navigation device Unv, i.e., of the user, using the received current position information Icp and the autonomous navigation information Ian (step S11). Here, the current position Pdtl is presumably represented by (Xdtl, Ydtl), in which Xdtl denotes a latitude coordinate of the navigation device Unv, and Ydtl a longitude coordinate thereof. The current position Pdtl is then stored onto the working area 3.

Detail Description Paragraph:
[0083] The processor 1 then operates as does a second calculation section in claim 3, more specifically, calculates a reference vector Vref (Xref, Yref) which defines in which direction the directional object Odr is facing with respect to the current position Pdtl of the navigation device Unv (FIG. 11; step S32). Here, Xref=Xbjd-Xdtl, and Yref=Ybjd-Ydtl. This reference vector Vref is stored in the working area 3.

Detail Description Paragraph:
[0093] After step S14, the processor 1 determines whether or not to perform route search (step S15). Step S15 is typically carried out as follows. A predetermined part of the input unit 7 (see FIG. 1) is assigned with a function of starting route search. If the user operates the part, the input unit 7 generates an instruction signal Sst, and transmit it to the processor 1 for instruction of route search.

Detail Description Paragraph:
[0094] Prior to step S15, if the processor 1 has not yet received the instruction signal Sst from the input unit 7, the procedure returns to step S11 to generate the display image data Ddp. If having received the instruction signal Sst from the input unit 7, the processor 1 accordingly performs route search (step S16). The route search is performed in a known manner, and will be briefly described below. The processor 1 searches for a route considered optimal from the user's starting point to the destination typically based on the Dijkstra's algorithm. During the route search, used is the road network data Dnt described referring to FIG. 2. Through such route search, the processor 1 generates route data Drt representing thus found optimal route on the working area 3. Here, the route data Drt is typically composed of node strings structuring the road network data Dnt. As already described, the nodes each specify the characteristic points on the road network by a pair of latitude and longitude coordinate values.

Detail Description Paragraph:
[0095] After deriving the route data Drt in step S16, the processor 1 goes through a guidance process (step S17) to generate the guidance image data Dgd for guiding the user to the destination.

Detail Description Paragraph:
[0098] In FIGS. 9 and 16, by the time when step S216 is through, the frame memory would have intermediate image data similar to the display image data Ddp in the above. As already described, the working area 3 stores the route data Drt. After step S216, the processor 1 renders the optimal route Rpt on the three-dimensional map (step S51). In step S51, the processor 1 extracts any nodes in the area .alpha.1 from the node strings of the route data Drt. The processor 1 then connects thus extracted nodes on the frame memory by a predetermined line so as to render the optimal route Rpt. By the time when step S51 is through, the frame memory would store the guidance image data Dgd representing the map including the optimal route Rpt and the indicator Ond.

Detail Description Paragraph:
[0099] After step S51, the procedure goes to step S44 of FIG. 15. The processor 1 transfers the guidance image data Dgd on the frame memory to the display 8 (step S44). The display 8 then goes through the display process in accordance with the

received guidance image data Dgd, and displays on its screen the map as shown in FIGS. 17A and 17B including the optimal route Rpt and the indicator Ond to guide the user to the destination.

Detail Description Paragraph:
[0106] Such a rendering device Urnd2 is incorporated into the navigation device Unv of the first embodiment. The data stored in the storage 4 is the same between the rendering devices Urnd1 and Urnd2. Thus, FIG. 2 is referred to in the below, and in the storage 4 of the rendering device Urnd2, any data identical to that stored in the storage 4 of the rendering device Urnd1 is provided with the same reference numeral, and not described below.

Detail Description Paragraph:
[0108] Described next is the operation of the navigation device Unv structured as above. On comparison with the processes of the first embodiment (FIGS. 8 to 11, 15, and 16), the navigation device Unv of the second embodiment carries out steps S61 and S62 of FIG. 20 as alternatives to steps S36 and S37 of FIG. 11. This is the only difference therebetween, and thus FIGS. 8 to 10, 15, and 16 are referred to in the below, and any step identical to that in the first embodiment is not described again. In FIG. 20, if the inner product Cdrm is positive in value in step S35, the processor 1 executes a process as do the rendering sections in claims 1 and 8, more specifically, starts rendering the message plane Ams of the directional object Odr (step S61).

Detail Description Paragraph:
[0114] Further, in the above embodiments, the rendering devices Urnd1 and Urnd2 are exemplarily incorporated into the navigation device Unv. Alternatively, those may be incorporated into any game machines displaying three-dimensional maps during car chase games, for example. If this is the case, there is no need to calculate the current position of the user, who moves. That is, the GPS receiver 5 and the autonomous navigation sensors 6 are not necessarily included in the rendering devices Urnd1 and Urnd2.

Detail Description Paragraph:
[0115] Further, the rendering devices Urnd1 and Urnd2 are receiving the directional object data Ddr from the storage 4 in the navigation device Unv in steps S12 and S42. This is not restrictive, and the rendering devices Urnd1 and Urnd2 may download the directional object data Ddr over the network typified by the Internet from the external server, for example, and store the data on the working area 3. Then, the procedure may go to step S12 or S42 and onward. That means the rendering devices Urnd1 and Urnd2 do not always require the storage 4.

Detail Description Paragraph:
[0116] In the above embodiments, the display image data Ddp and the guidance image data Dgd generated by the rendering devices Urnd1 and Urnd2 are transferred to the display 8 in the navigation device Unv. This is not restrictive, and the rendering devices Urnd1 and Urnd2 may transmit those data over the network to a navigation device locating far, and the navigation device may apply the display process to the received data. That means, the display 8 is not a must for the rendering devices Urnd1 and Urnd2.

Detail Description Paragraph:
[0117] Further, the rendering program 21 and the navigation program 22 in the above may be distributed in the form of a recording medium typified by CD-ROMs, or over the network.

CLAIMS:

9. A navigation device for guiding a user, comprising: a calculation section for calculating the user's current position; and a reception section for externally

receiving directional object data, wherein said directional object data represents a directional object which is a structure element of a map, and a plurality of planes of the directional object are facing in each different direction, and said navigation device further comprises: a rendering section for rendering the planes of the directional object in each different manner based on a positional relationship between the user's current position calculated by said calculation section and the directional object represented by the directional object data received by said reception section, and generating display image data representing the map; and a display for displaying the map according to the display image data generated by said rendering section.

10. A navigation method for guiding a user using a map on a display, comprising: a calculation step of calculating the user's current position; and a reception step of externally receiving directional object data, wherein said directional object data represents a directional object which is a structure element of said map, and a plurality of planes of the directional object are facing in each different direction, and said navigation method further comprises: a rendering step of rendering the planes of the directional object in each different manner based on a positional relationship between the user's current position calculated in said calculation step and the directional object represented by the directional object data received in said reception step, and generating display image data representing the map; and a transfer step of transferring the display image data generated in said rendering step to said display, wherein said display displays the map by applying a display process to the display image data transferred in said transfer step.